Deep Convective Cloud Calibration

D. R. Doelling, A. V. Gambheer
Analytical Services and Materials, Inc., Hampton, VA 23666
J. C. Stassi
SAIC, Hampton, VA 23666

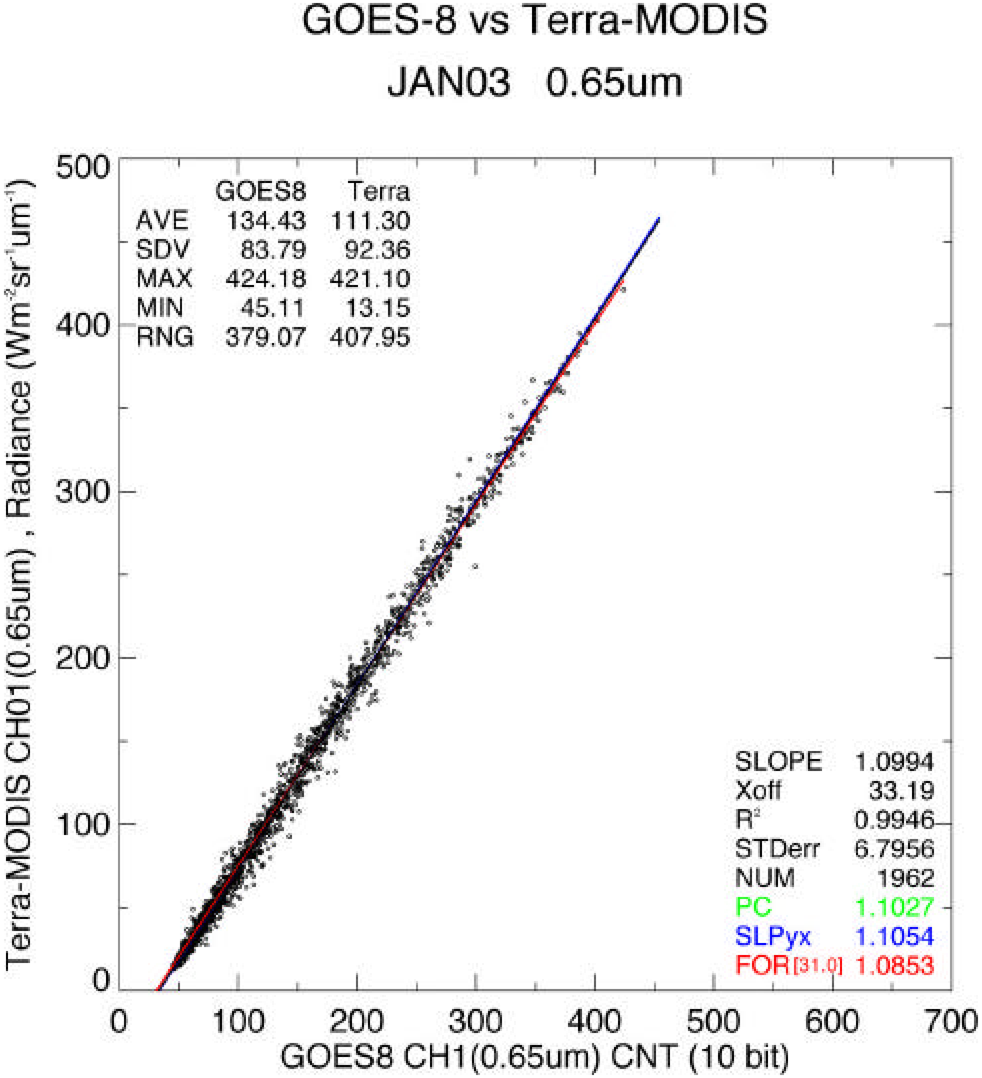
L. Nguyen, D. F. Young, Y. Hu, P. Minnis,

NASA Langley Research Center, Hampton, VA

Matched angle technique

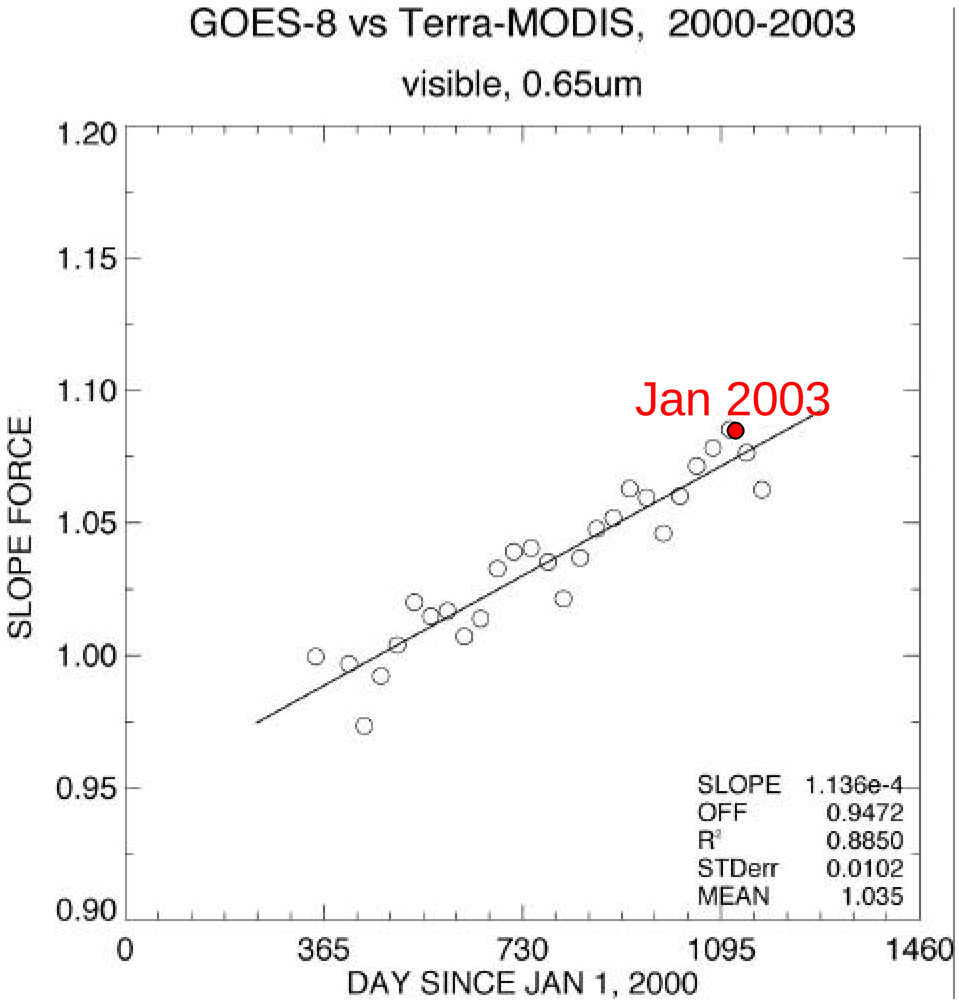
- Transfer calibration of MODIS (calibrated in the visible by solar diffuser) to Geostationary satellite (uncalibrated) by matching coincident, co-located, co-angled radiances
  - Bin visible pixel level radiances into 0.5° latitude by longitude regions (for GGEO 1° regions)
  - Time match within 15 minutes
  - Angle match within 5° view angle and 15° azimuth (for GGEO 10° view and 45° azimuth)

GOES-8 vs Terra-MODIS monthly regression for Jan 2003

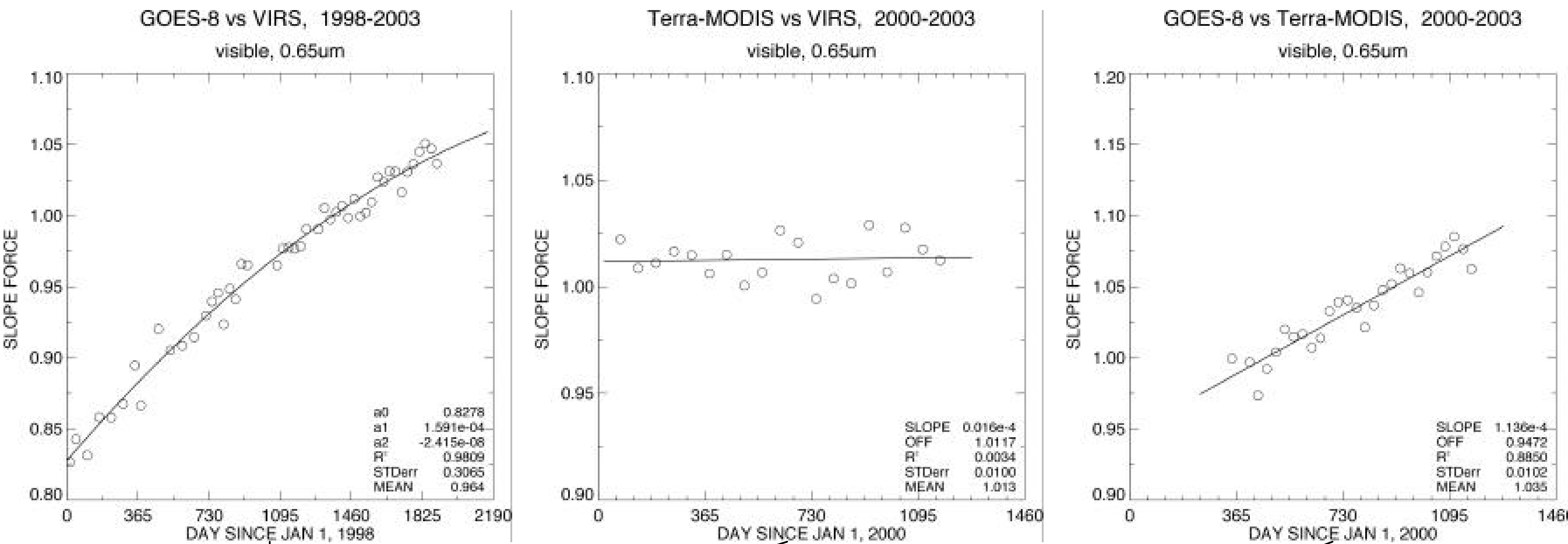


Force fit relies on a fixed offset and the mean

GOES-8 vs Terra-MODIS timeline

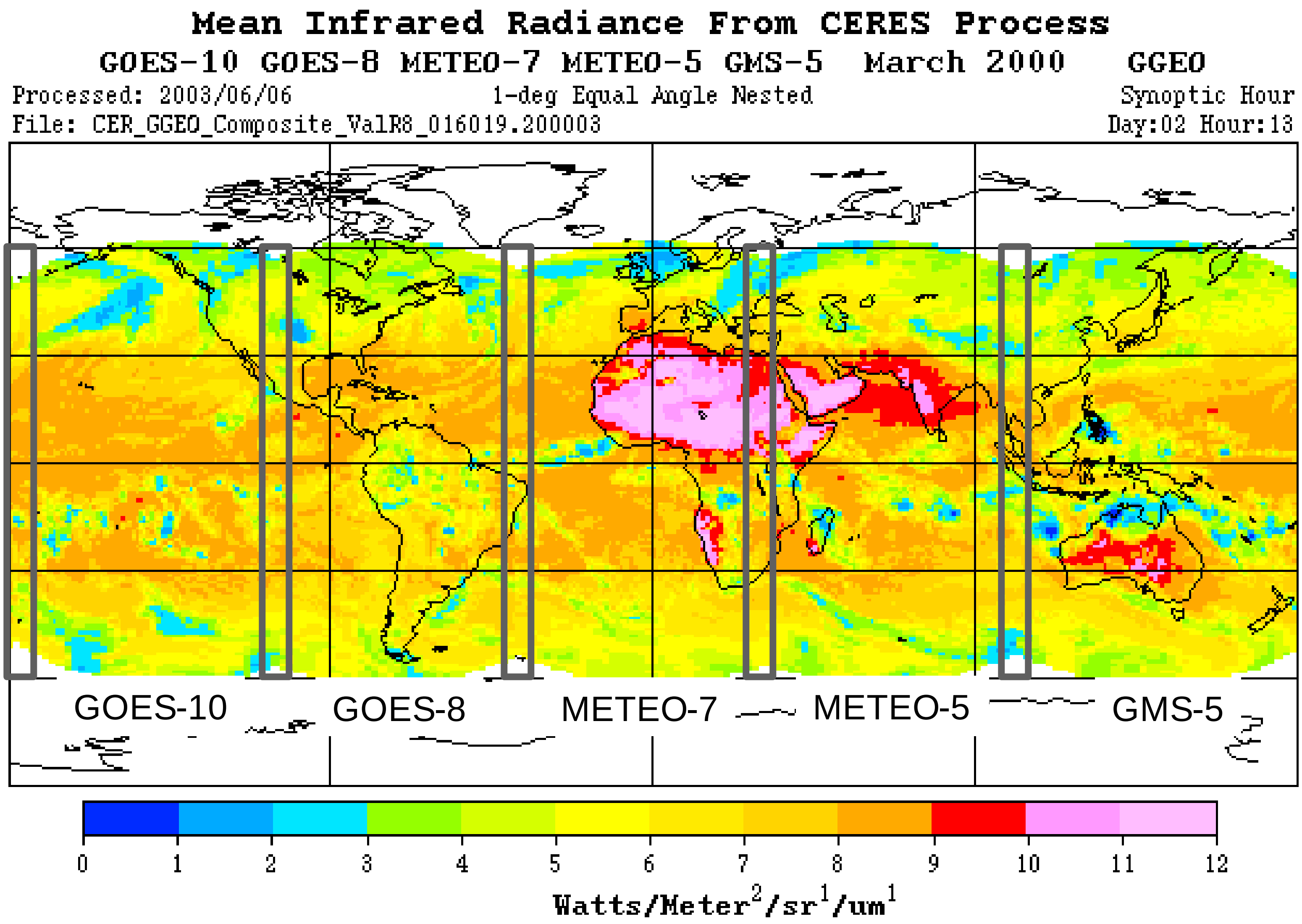


3 way matched angle cross-calibration validation

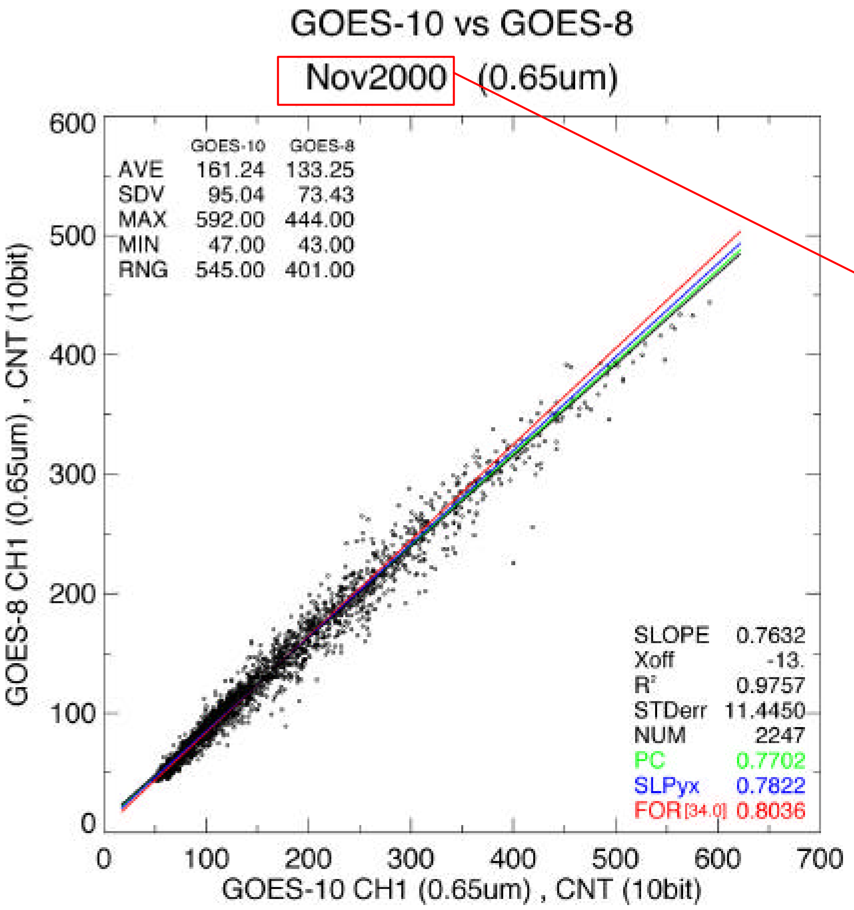


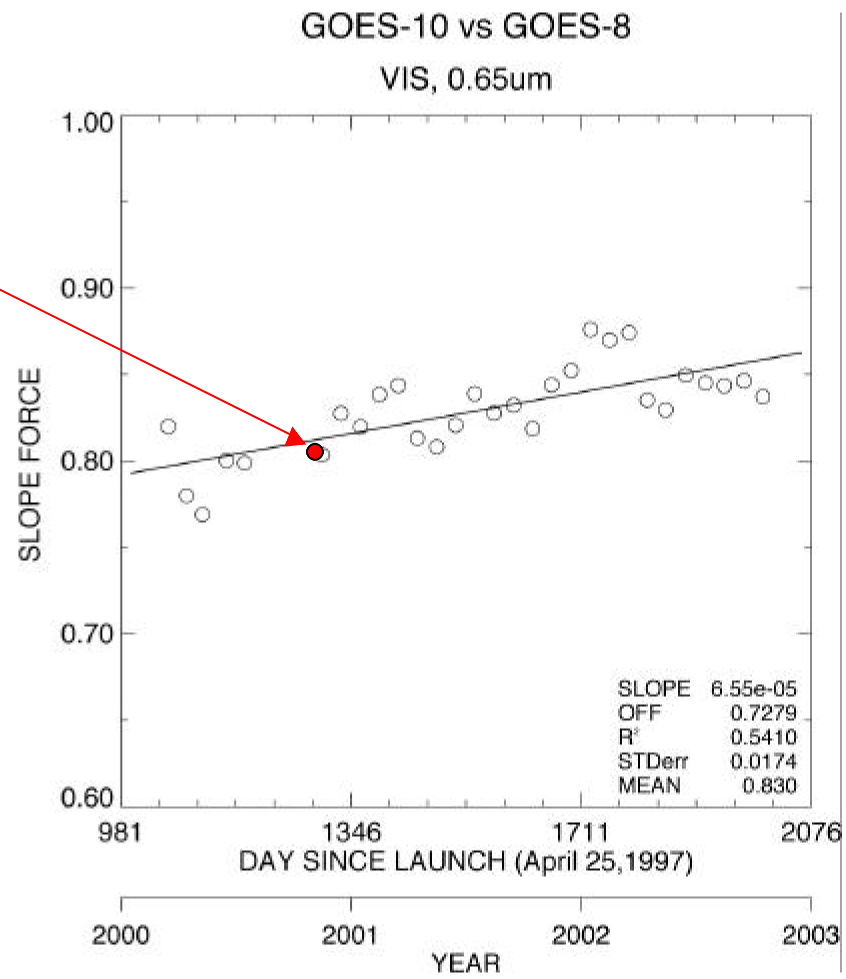
	VIRS / GOES-8	*	MODIS / VIRS	=	MODIS / GOES-8	From timeline	difference
Jan 2001	0.9730		1.012		.9847	0.9887	0.4%

GGEO noon cross-calibration regions



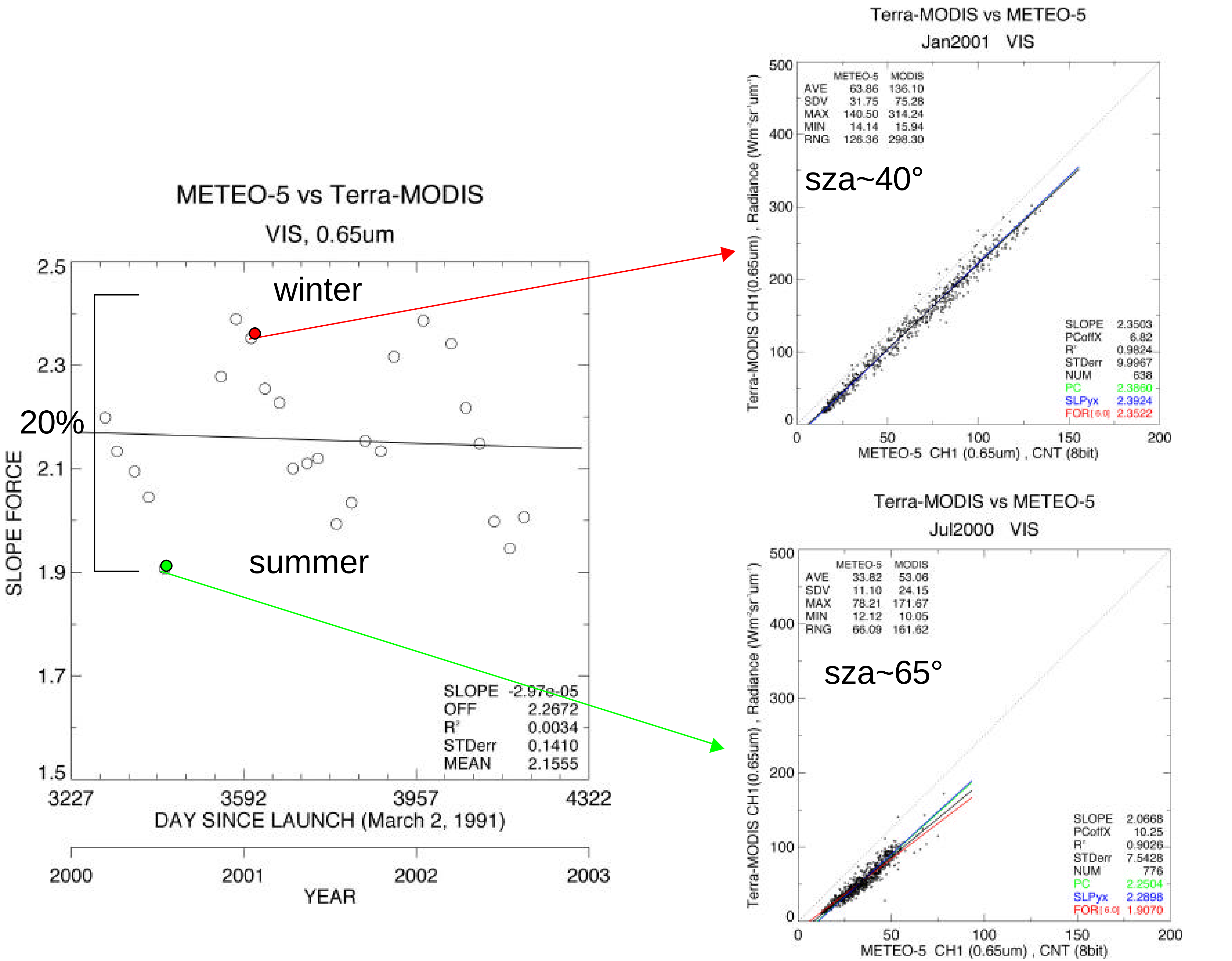
GOES-10 to GOES-8 noon cross-calibration during 2000-2003





What happens operationally

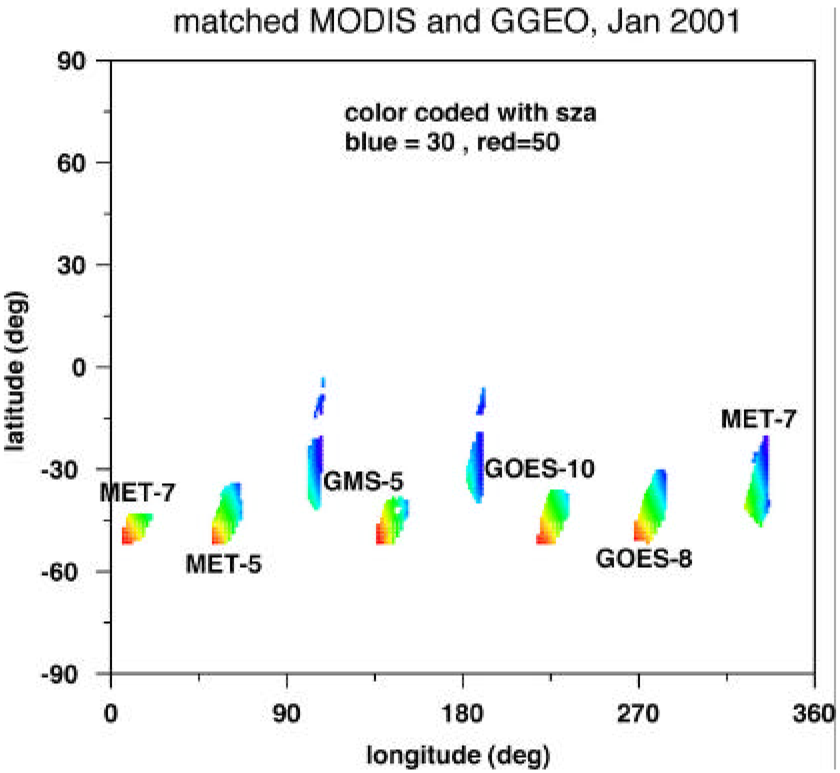
- Matched angle conditions between 3 hourly geostationary and polar orbiter data tend to have preferred geographical locations and solar zenith angles that vary seasonally
- Navigation problems



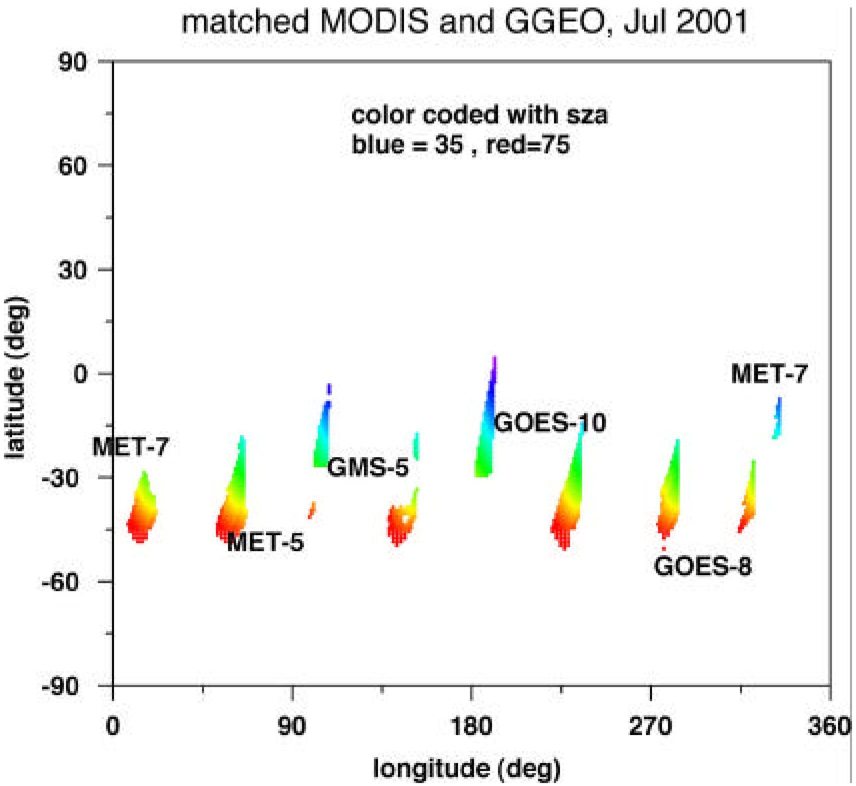
METEO-5 vs Terra-MODIS
VIS, 0.65um
winter
summer
20%
SLOPE FORCE
DAY SINCE LAUNCH (March 2, 1991)
YEAR
SLOPE -2.97e-05
OFF 2.2672
R² 0.0034
STDerr 0.1410
MEAN 2.1555
Terra-MODIS vs METEO-5
Jan2001 VIS
METEO-5 MODIS
AVE 63.86 136.10
SDV 31.75 75.28
MAX 140.50 314.24
MIN 14.14 15.94
RNG 126.36 298.30
sza~40°
SLOPE 2.3503
PCoffX 6.82
R² 0.9824
STDerr 9.9967
NUM 638
PC 2.3660
SLPyx 2.3924
FOR 2.3522
Terra-MODIS CH1(0.65um) , Radiance (Wm⁻²sr⁻¹um⁻¹)
METEO-5 CH1 (0.65um) , CNT (8bit)
Terra-MODIS vs METEO-5
Jul2000 VIS
METEO-5 MODIS
AVE 33.82 53.06
SDV 11.10 24.15
MAX 78.21 171.67
MIN 12.12 10.05
RNG 66.09 161.62
sza~65°
SLOPE 2.0668
PCoffX 10.25
R² 0.9026
STDerr 7.5428
NUM 776
PC 2.2504
SLPyx 2.2898
FOR 1.9070
Terra-MODIS CH1(0.65um) , Radiance (Wm⁻²sr⁻¹um⁻¹)
METEO-5 CH1 (0.65um) , CNT (8bit)

Matched angle spatial sampling

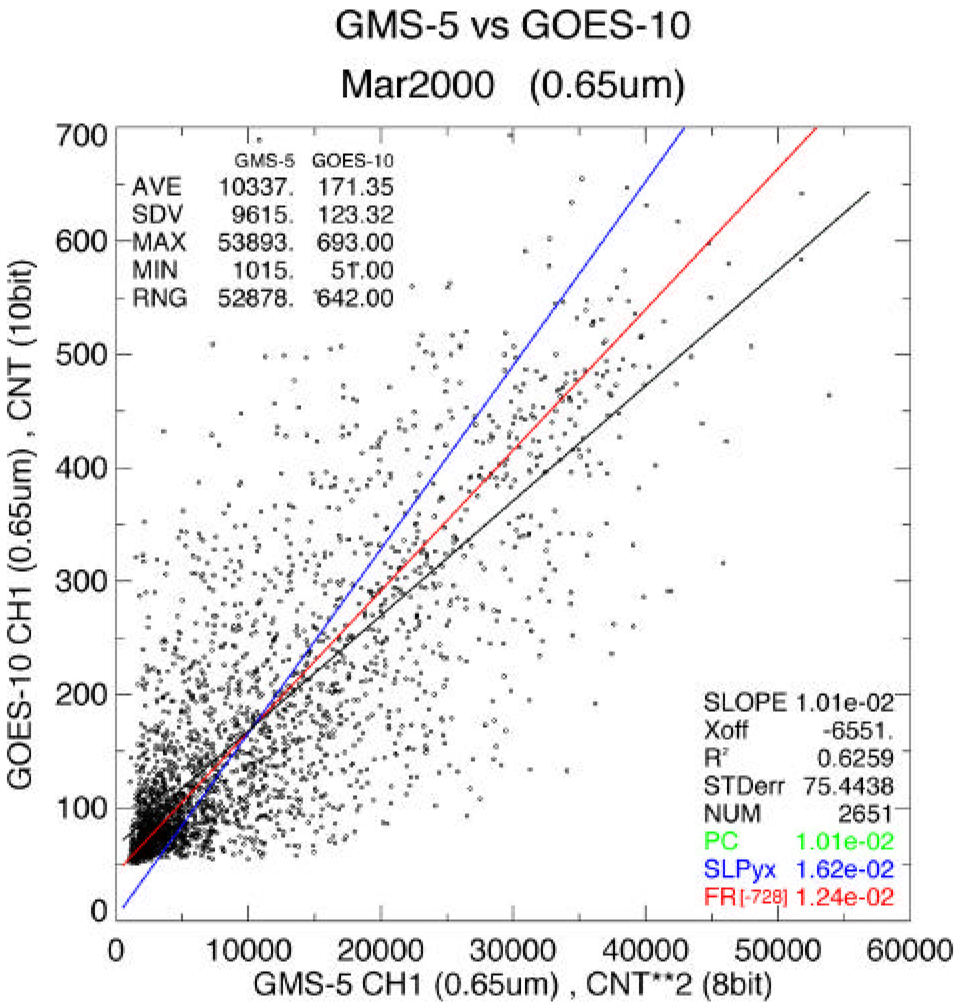
Winter



Summer



GMS-5 navigational problems

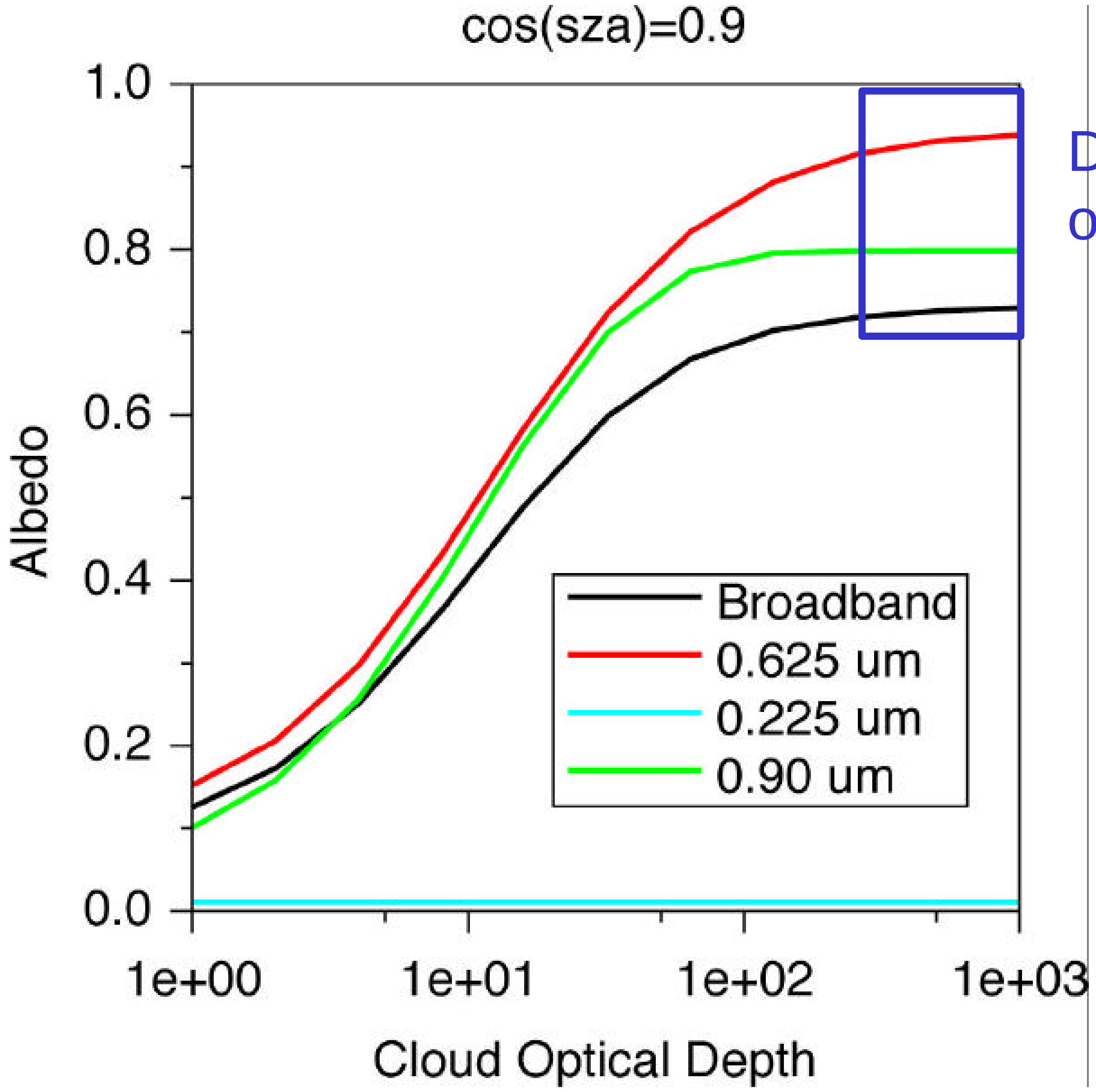


Deep Convective Cloud Calibration

- Based on the assumption that there is maximum TOA albedo a cloud can have no matter how optically thick the cloud
- Can be used to detect relative gain drift in the visible sensor

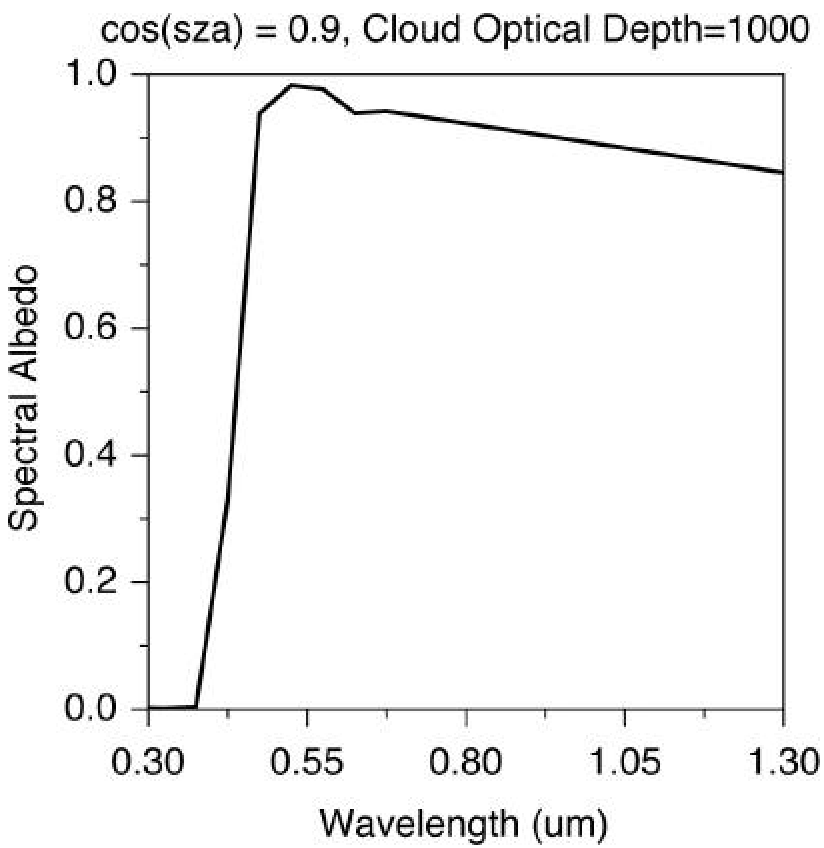
Deep Convective Cloud Calibration

- At what optical depth does the TOA albedo stabilize, where cloud reflectivity and absorption balance?
- Fu-Liou radiative transfer code
  - McClatchey Tropical Profile
  - 10km thick ice cloud over ocean
  - 60µm particle size
  - Vary cloud optical depth from 1 to 1000



Deep convective
optical depths

Deep convective spectral albedo



Deep convective directional models

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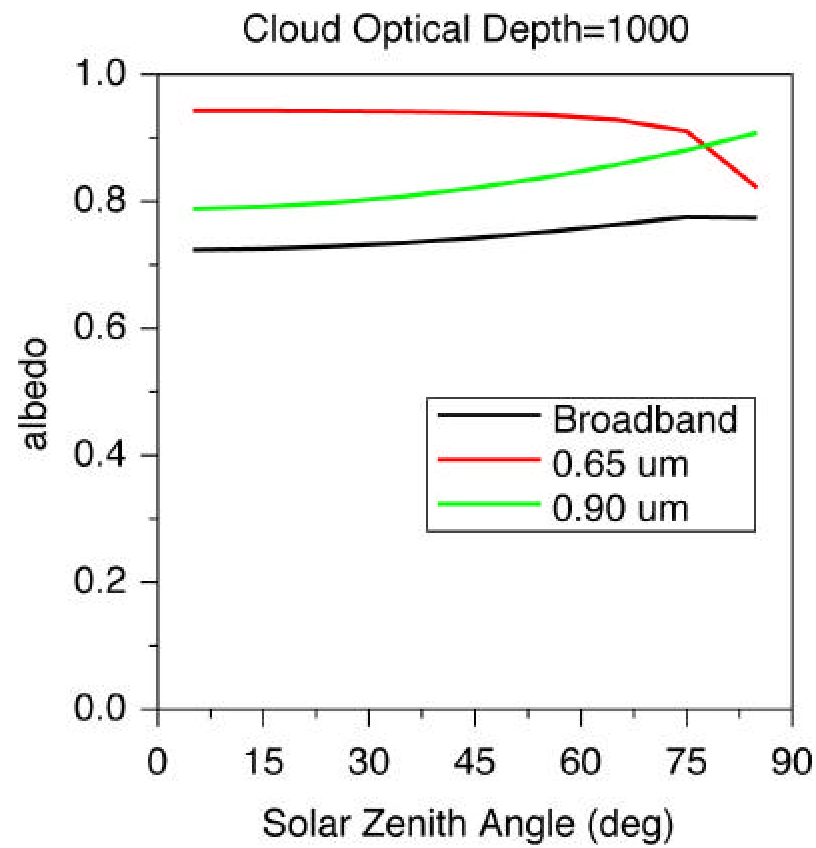
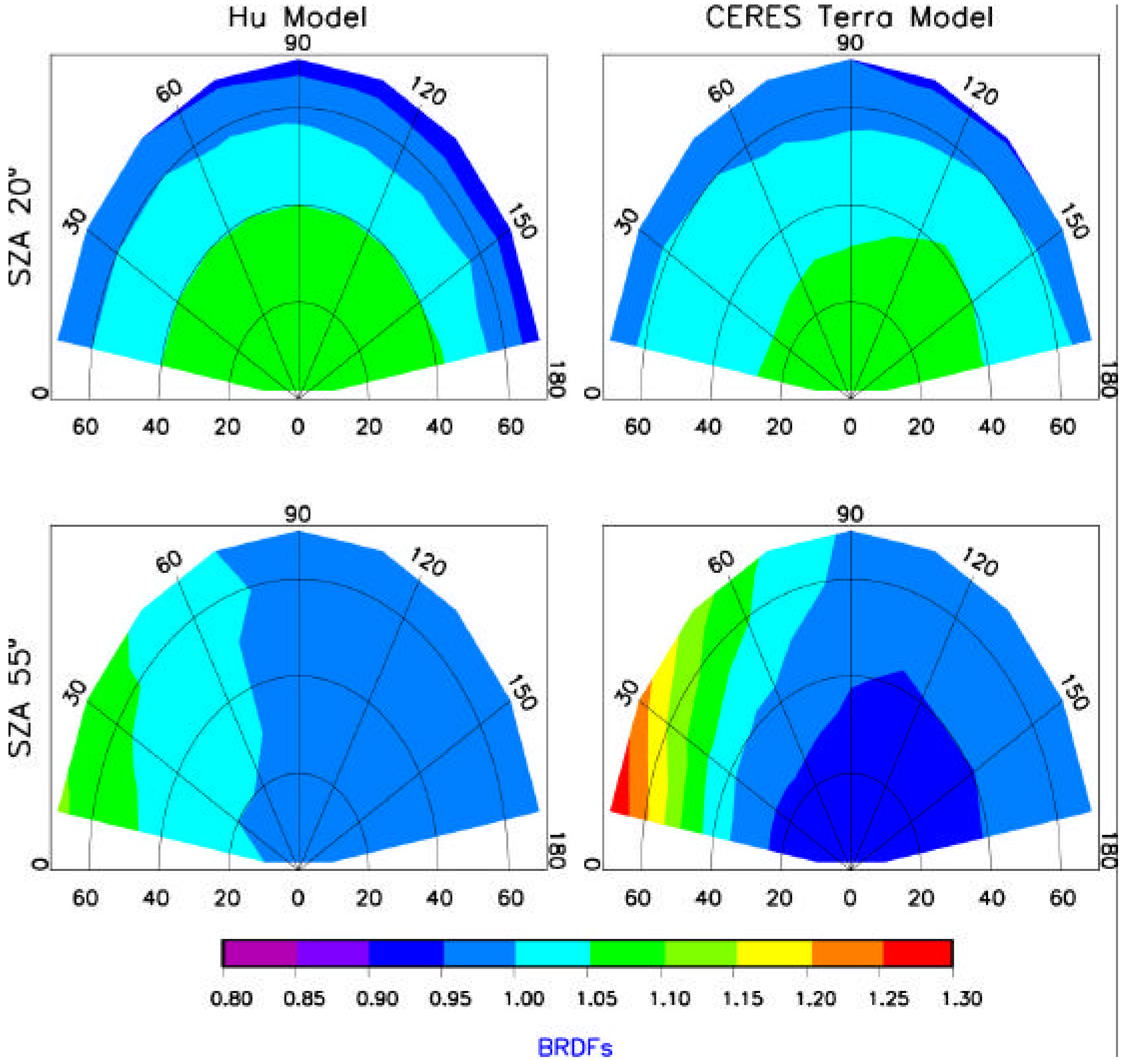


Deep convective cloud bidirectional models

- Hu Model
  - MODTRAN absorption
  - DISORT scattering
  - Ice cloud at 120 optical depth
  - Broadband model
- Terra Model
  - Bin CERES footprints into angular bins where the
  - MODIS 11µm Temperature < 205° K
  - Optical depth > 20
  - Ice cloud amount > 99%
- How lambertion are deep convective clouds?

Deep convective cloud bidirectional models

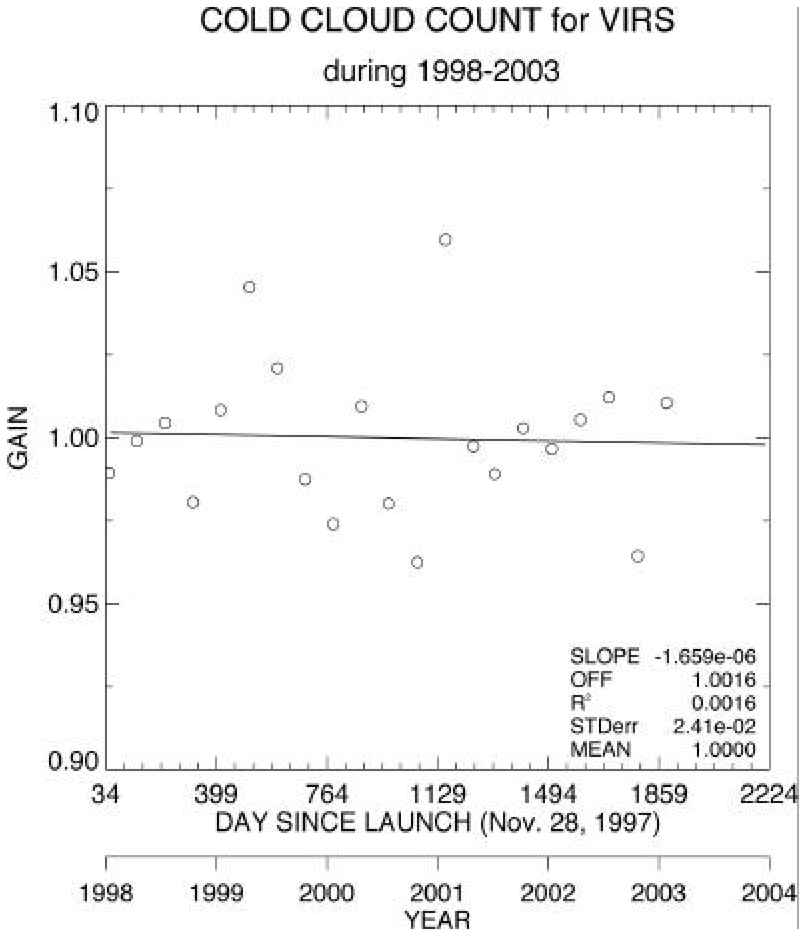


Test deep convective technique on VIRS data

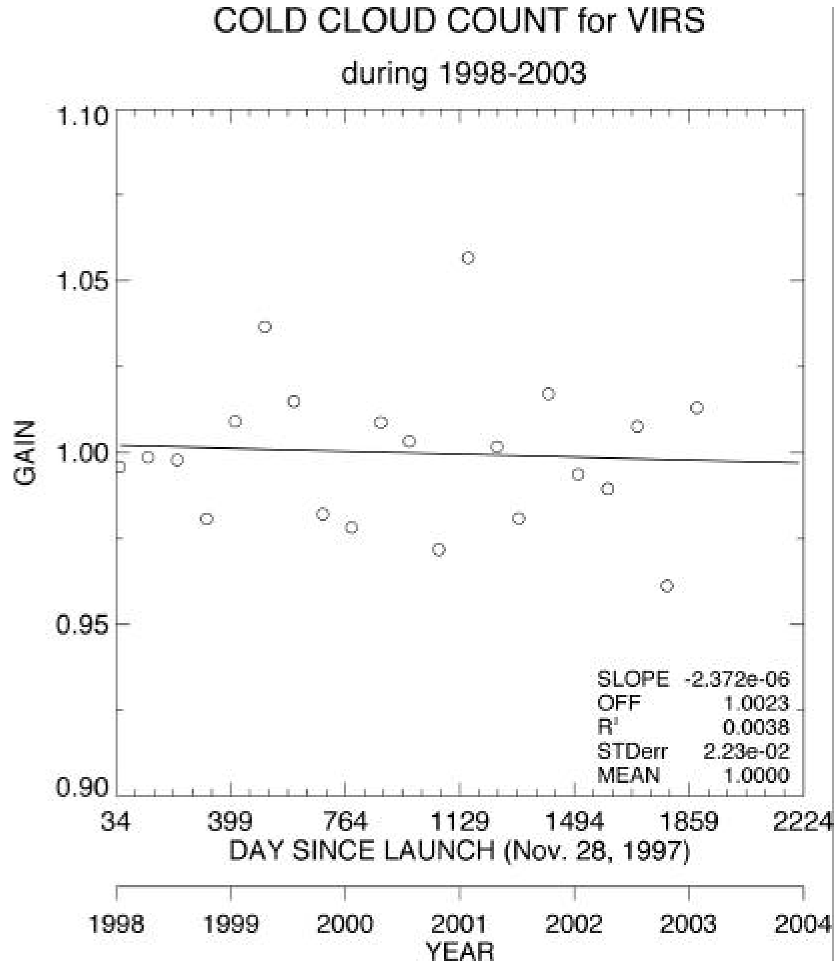
- VIRS has a visible solar diffuser - should see no temporal drift if done correctly
- Use all pixels < 205° K
- Limit bidirectional effects
  - Limit solar zenith angle <40° and view angle < 40°
  - Bin visible radiances into 10° solar zenith, 10° view and 20° azimuth angle bins
  - Take mean of all sampled bins for a single precessionary (23 day) cycle (reduces the effects of preferential seasonally dependent angular bins
- Use 4 precessionary cycles per year from 1998-2003
- Compare timeline from Hu and Terra model

VIRS deep convection timeline

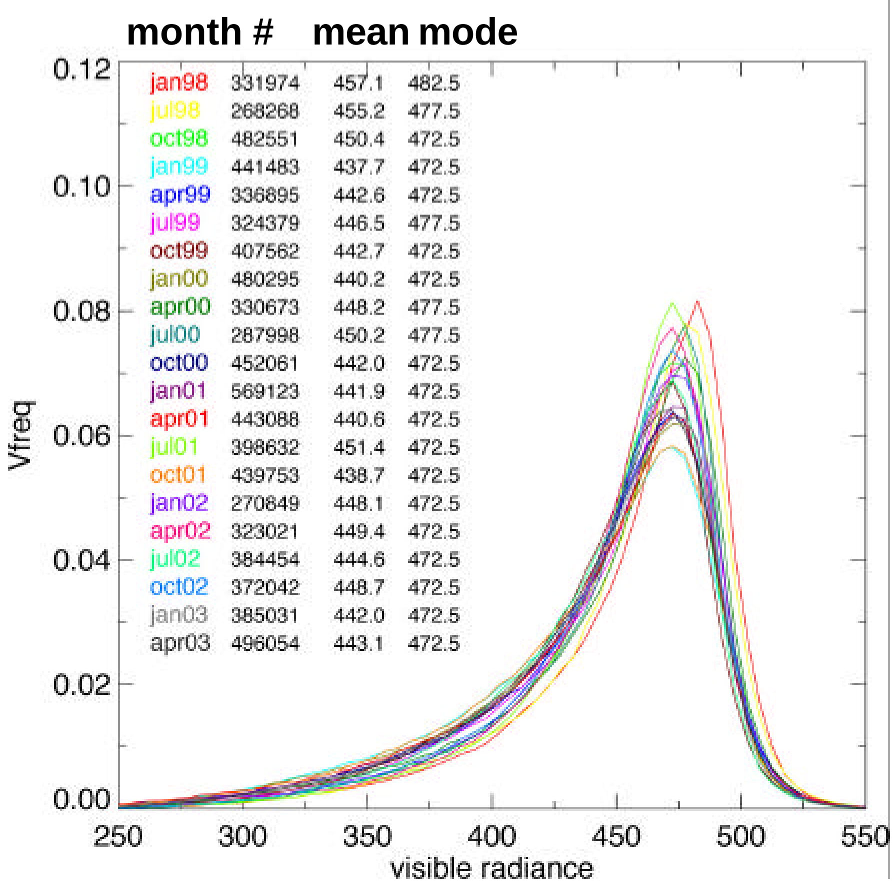
HU



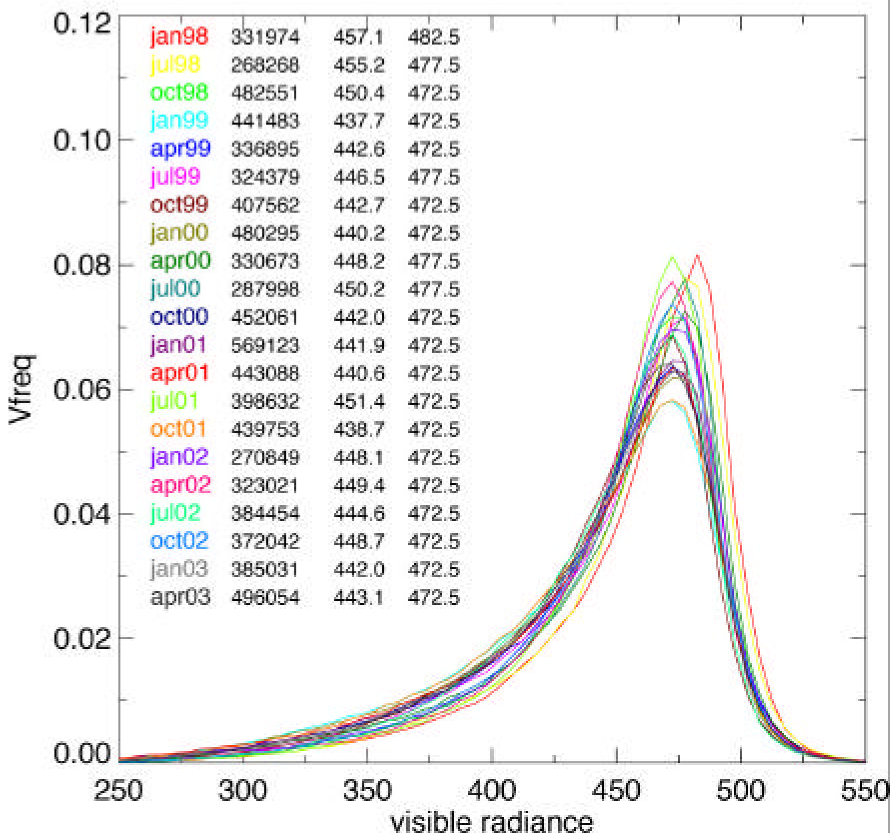
Terra

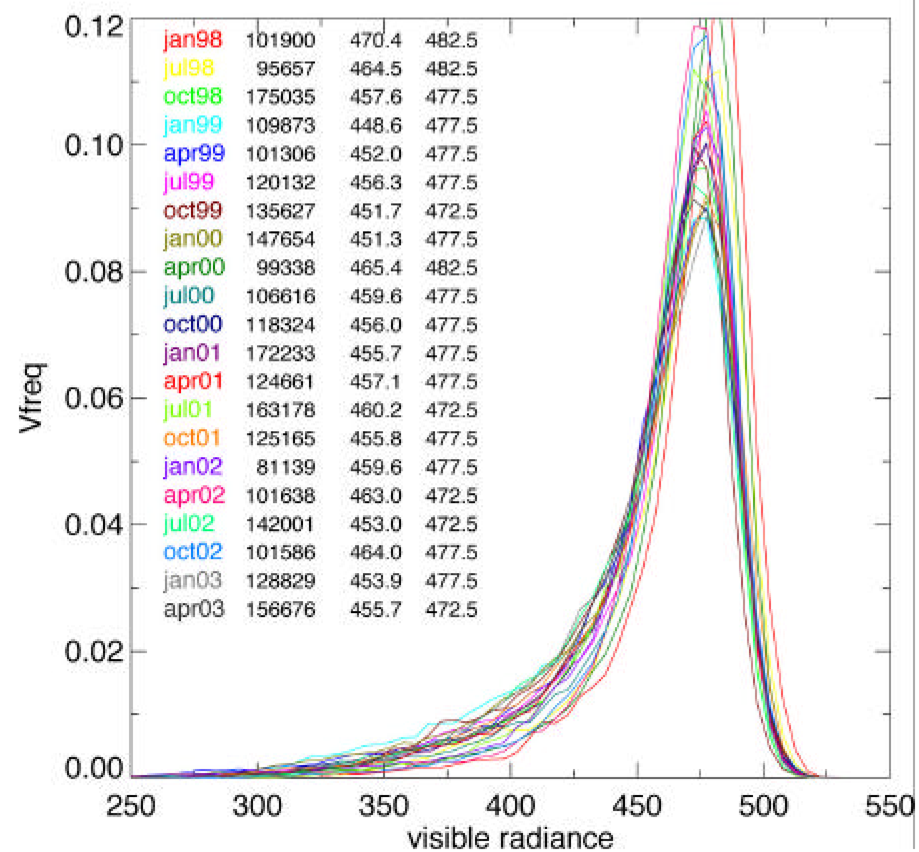


VIRS Visible radiance PDF for pixels with Temperature < 205°K



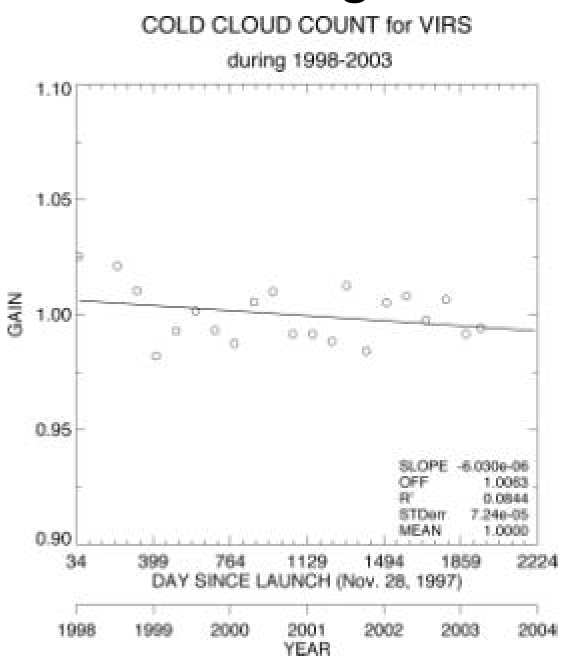
- Sharpen PDF by using only pixels where the surrounding 8 pixels have a visible sigma < 8 $Wm^{-2}Sr^{-1}um^{-1}$ and a Temperature sigma < 1°K to reduce 3-D effects



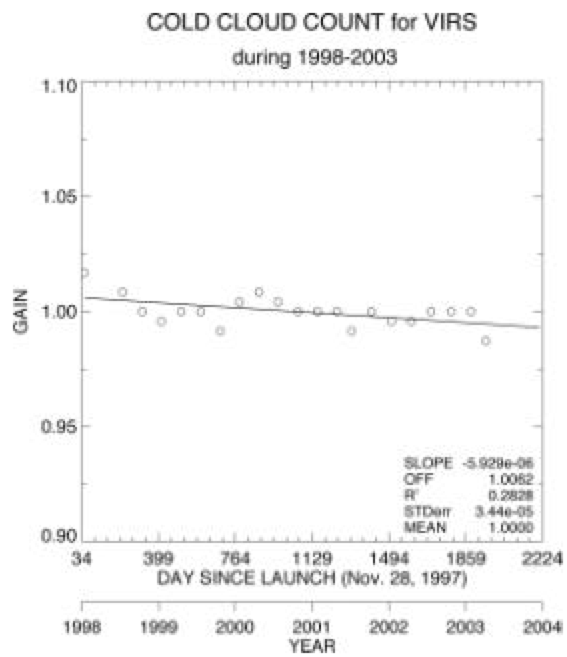


Comparison of VIRS deep convective timeline techniques

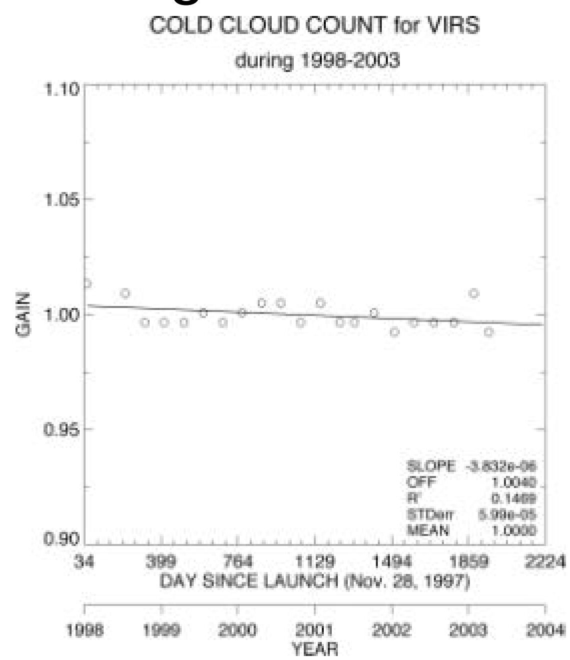
Low sigma



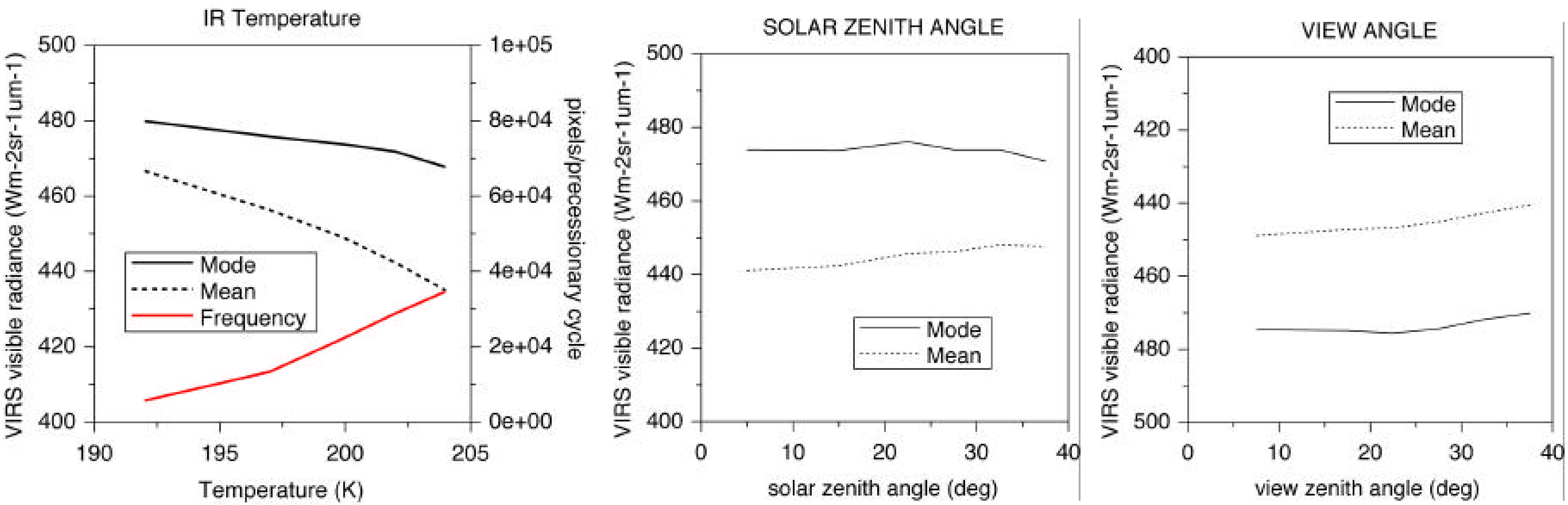
Mode



Low sigma & Mode

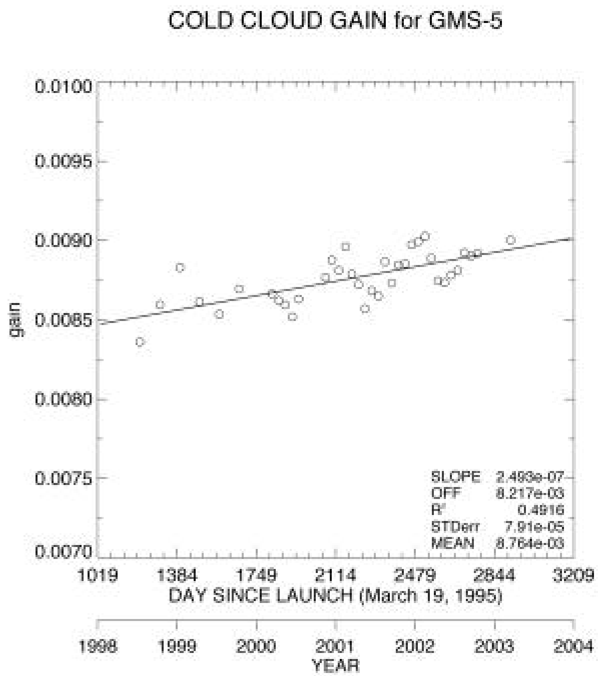


VIRS deep convective dependencies

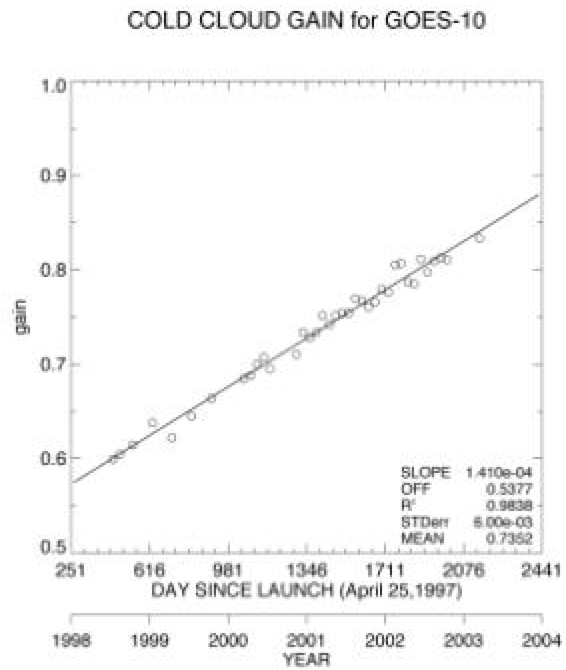


GGEO deep convective timelines using angular bin technique

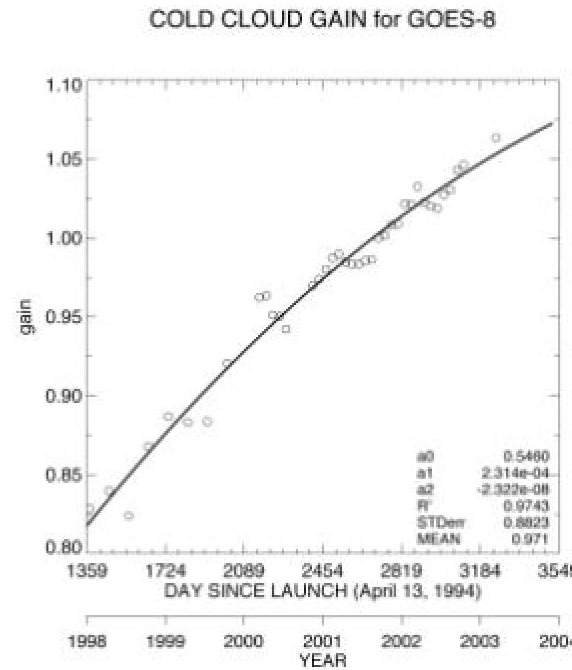
GMS-5



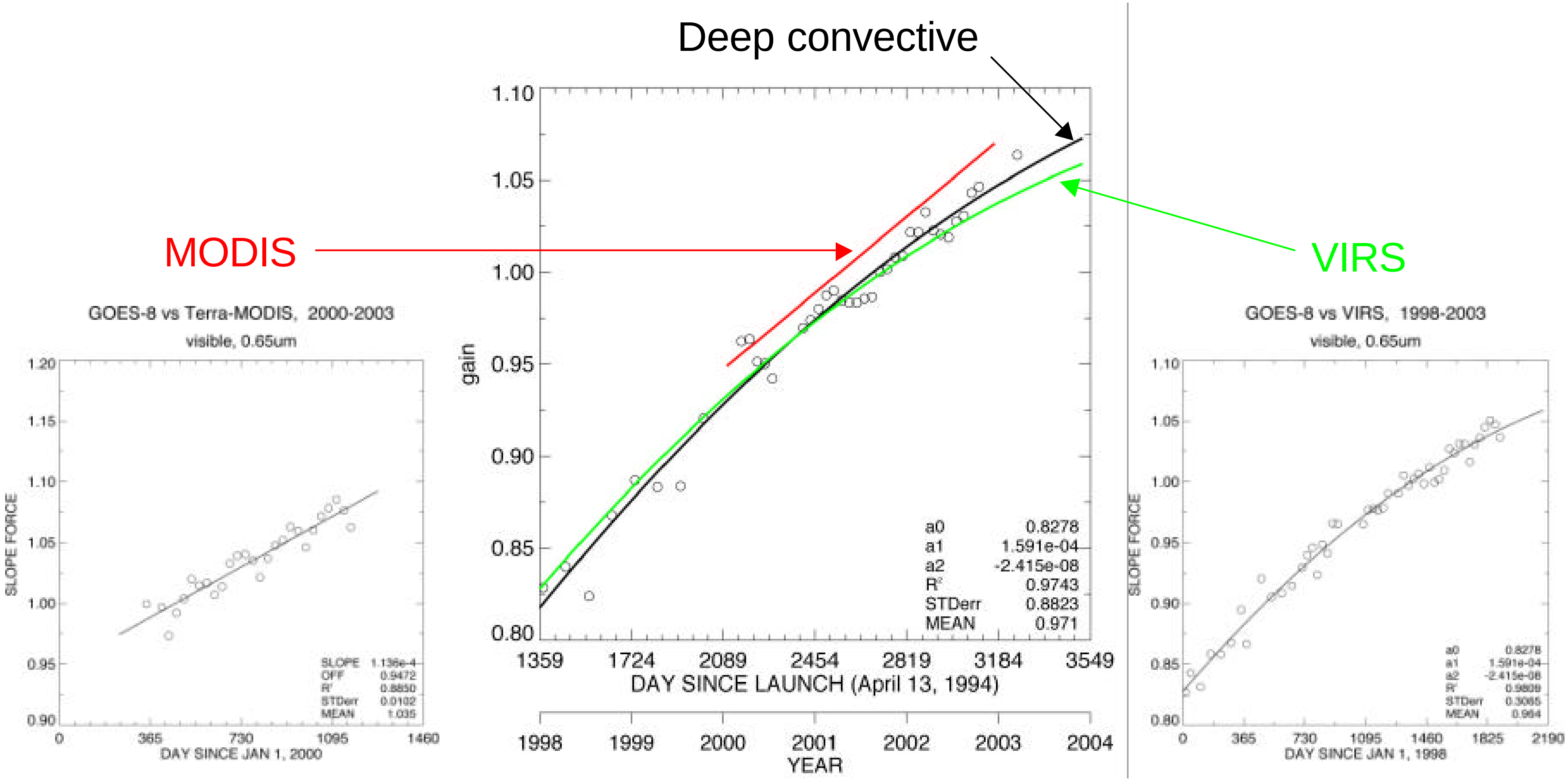
GOES-10



GOES-8



Comparison of GOES-8 calibrations



Conclusions

- Deep convective clouds can provide relative gain for non-calibrated visible instruments
  - Does not rely navigation
  - Does not need continuous monitoring of a calibrated visible source
  - Is well suited for operational calibration updating
- Use deep convective GGEO calibration as a sanity check of the current calibrations derived from MODIS in conjunction with noon GGEO cross-calibration